SMARTGUIDER

User Manual

- version 1.0 -

1. Item Checklist

Thank you for purchasing the LVI SmartGuider autoguiding camera!
Upon receipt, please check that your package is complete and contains the following items:

1. Control handlepaddle ("Control Paddle").
2. SmartGuider camera head
3. One power supply cable
4. One 8-pin RJ cable (Control paddle to camera head)
5. One 6-pin RJ cable (Control paddle to mount's ST-4 port)
6. User's manual

2. Quick Start Guide

Thanks to its ease of use, you can hook up your SmartGuider and be ready within minutes. Once your imaging rig has been set up, polar aligned and carefully balanced, here are the main steps to follow:

1. Make all the necessary connections:
   a. Attach the camera to the guide scope, carefully locking the setscrews.
   b. Connect the Control Paddle to both the camera head and the mount's ST-4 port using the appropriate RJ cables.
   c. Connect the Control Paddle to a 12V DC power supply.
2. Turn the LVI SmartGuider on
3. Search for a suitable guide star
4. Focus with the SmartEye parfocal eyepiece (*)
5. Calibrate the mount (*)
6. Set the camera's advanced options (*)
7. Start autoguiding.

(*) The steps marked with a star, such as focusing and calibration, could not always be necessary. Please consult Section 4 ("Tips and Tricks") for details.

3. Using the SmartGuider

The SmartGuider's control paddle features a wide pixel matrix screen, whose colors (red pixels on a black background) and brightness do not compromise the eye's delicate adaptation to darkness.

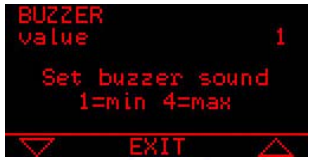
In this section we describe the content and functionality of all of the available user screens: for a quick and effective overview of their usage, please check out the flowchart available in the download section of LVI's web site. Most screens can have up to three different options on their bottom line, which can be activated by pressing the corresponding button on the control paddle (from left to right).

After connecting the power supply, **turn the camera on by pressing and holding the central button** until the LVI logo shows up; shortly thereafter, the message "**YOUR SMARTGUIDER IS READY**" informs you that the startup phase is complete and the camera has come online.
Press **OK** to go to the **first user screen**:

In the above screen, you can turn off the camera by pressing and holding the left button (**OFF**), while selecting **BASIC** with the central button will take you to the **basic settings screen (MENU BASIC)**:

With **EXIT** you can go back to the previous menu, while **FOCUS** takes you to the next step (guide star focusing). **OPTION** enables to adjust the display and keyboard **backlight** level and the buzzer **volume**.

The two basic settings menus are shown below: **brightness** (left) and **buzzer** volume (right):



You can adjust both the brightness and the buzzer volume with the two triangular keys on the control paddle: four levels are available, from 1 (minimum) to 4 (maximum). **EXIT** takes you back to the basic settings screen.

Now let's have a closer look at the focusing procedure.
Before mounting the camera onto the guide scope's drawtube, you have first to center the brightest star in the field of view which is closest to your imaging target with a wide-field, low-power eyepiece; use then the special SmartEye eyepiece to focus the guide scope and fine tune the position of the star chosen. This special eyepiece will deliver a perfectly focused star and centered in the camera's field of view.

When you press on **FOCUS,** the SmartGuider scans the whole frame for the previously selected guide star:

After a while (the actual duration of the search phase is not always the same), the SmartGuider will inform you of the outcome with a simple message: "**STAR FOUND!"** or "**STAR NOT FOUND!**":

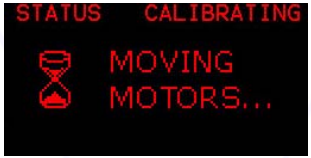
If the guide star was not found (upper right), the SmartGuider goes automatically back to the **MENU BASIC** screen: in this case a brighter star has to be chosen. If the star has been found (upper left), we can proceed to the important **focusing menu**:

In this screen, the X and Y offsets (1 offset unit = 4 sensor pixels) denote the position of the guide star relative to the detector center, and the small cross in the rectangular box (see above) indicates the star's approximate location in a graphical form. *If the star happens to be lying too close to the sensor's edges (Bounds: X OFFSET ±82, Y OFFSET ±46), you can try to center it by CAREFULLY nudging the mount along the four directions with the drive keypad at guiding speed.* If the star is thrown off the active area, it will be lost (**STAR LOST** message pops up) and you will have to start over with focusing.

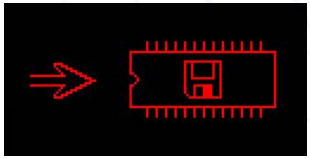
Two focusing aids are available: the **FOCUS STAR** index and the circle on the right-hand side of the screen: they both show the diameter of the star (in pixels) on the detector in numerical and graphical form respectively. Therefore, the lower

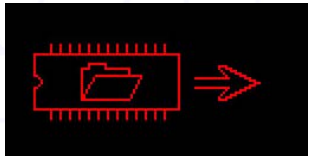
the number, the better the focus: a properly focused star should be 3 to 8 pixels wide according to the brightness and air turbulence.

Once the guide star has been correctly centered and focused, we can select **CALIBR** to get to the **calibration screen**: press **OK** to start calibrating the mount.

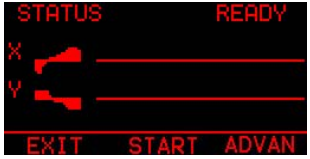


The calibration process can last up to a few minutes. Upon completion, the new calibration parameters are automatically stored into the camera's non-volatile memory (the **SAVE** icon showed here on the bottom left). In case you want to reuse the parameters from last calibration, just choose **LOAD** from the focusing menu (screen on the lower right). *Please see note on calibration on page 9*.





At this point we come to the **autoguiding screens**:



The SmartGuider is standing by (**Status: READY**, screen on the upper left) before starting the actual autoguiding phase (**Status: GUIDING**, screen on the

upper right) by selecting **START**. The two graphs allow real-time monitoring of guiding corrections issued to the mount. You can interrupt the autoguiding process by pressing STOP at any time, while **EXIT** will take you back to the basic settings screen.

At times the guide star may be lost (1 beep per second and **STAR LOST**): this can be due to a number of different reasons, e.g. because the sky has clouded over, the optics have dewed up, or the star has been thrown off the field of view by a wind gust or even because the telescope has been touched. If the star remains invisible for **up to 30 seconds**, the camera will still be able to resume autoguiding; otherwise, the current session is aborted and the execution flow goes back to the **MENU BASIC** screen to search for a new guide star.

From the autoguiding screen, pressing the **ADVAN** menu item brings up the advanced settings screen:

EXIT will take us back to the previous menu, while by pressing **AGGRESS X** we come to the following screens:

With the two triangular arrows (**UP** and **DOWN**), you can adjust the aggressiveness in the X axis (upper left) and in the Y axis (upper right).
The aggressiveness in both axes can range from 1 to 6 (1-2=LOW, 3-4=MILD, 5-6=HIGH) and expresses the degree of reactivity of corrections: a high value will urge the camera to immediately correct for the slightest displacement, whereas a low value will yield a much smoother behavior. .

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4. Tips and Tricks

The SmartGuider is very simple and intuitive to use. However there are some phases, namely selection of a suitable guide star, focusing and calibration, which are critical in maximizing the performance of your SmartGuider and therefore deserve special attention. For further details, please check out our website: www.lvi-cameras.com.

Error messages

If for any reason the guide star has been lost, the SmartGuider warns the user with both an error message ("**STAR LOST**!") and an audible signal (one beep per second until the star becomes visible again, for up to 30 seconds).

If the cable connecting the CPU and the camera head gets accidentally disconnected, or in case of problems with the electrical connections or the power supply, the following message is displayed: "**COMMUNICATION ERROR**!".

Choosing a suitable guide scope

Thanks to its features, the SmartGuider does not call for telescopes with very long focal length or particularly wide aperture. As a rule of thumb, when imaging with digital SLRs or CCDs (pixel size between 5 and 8 microns), the guide scope should have about the same focal length as that of the main instrument; for bigger-sized pixels, shorter focal lengths are equally suitable. In any case, it is advisable to use refractors instead of slow catadioptric reflectors (e.g. Maksutovs with f/ratio of 10 and upwards), since focusing by movable primary mirror can easily lead to exposure trailing even if the tracking performance looks apparently good. Moreover, there are cases where high magnification is not always an advantage, due to lower brightness and increased sensitivity to atmospheric turbulence (*seeing*).

Brightness of the guide star

The SmartGuider automatically adjusts the exposure time according to the guide star's brightness: shorter for bright stars, longer for dim ones. This also affects the frequency of corrections to the mount: bright stars allow for continuous position control, which also ensures that all sorts of tracking errors, including the component resulting from periodic error and atmospheric turbulence, will be easily guided out. Bright stars are best to compensate for the most erratic periodic errors, or with guide scopes having a shorter focal length than that of the main optics. In this case, we advice setting the guide speed to a mid to low value (0.15 – 0.40X), with HIGH aggressiveness.

On the other hand, fainter stars imply a less frequent correction of tracking errors: this makes them not as suitable for mounts with an irregular periodic error. However, long exposure times required by faint stars could come in handy to minimize the influence of bad seeing. Here we suggest that the guide speed be set to slightly higher values (0.30 – 0.50X) but with lower (i.e. MILD) aggressiveness.

Medium brightness stars (visual magnitude between 3 and 6) generally yield best performance.

Search of a guide star by the SmartGuider

During this process, the telescope must not be touched at all, nor can the drive motors be operated! If (and only if) the search for the guide star fails, you can operate the mount to find a brighter star or to better center the current one in the field of view.

If the camera does not manage to find a sufficiently bright star, a micrometric guide scope support will help; and in case an off-axis guider is being used, the pick-off prism and tube can be moved and/or rotated to find a brighter star.

Mount calibration

Once calibration is over, the parameters are permanently stored into the SmartGuider's internal memory (EEPROM) for later use, provided that the following precautions are taken into account:

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1. Always guide on stars lying in the same side of the sky (with respect to the local meridian) as that where the calibration was last performed;
2. NEVER take the camera off the guide scope;
3. NEVER rotate the camera in the guide scope focuser.

In all other cases, the camera must **always** be recalibrated.

It can take a relatively long time for the calibration process to complete, especially with guide scopes of short focal length (under 500 mm) and low guiding speed (i.e. less than 0.5 X).

Of course, the telescope must not be touched during calibration, otherwise the relevant parameters could not be calculated correctly. This also applies to all kinds of external perturbations (e.g. wind gusts).

It is also advisable not to use too dim a star for calibration, otherwise just a simple bank of cirrus clouds or a little dew on the lenses could cause the star to be lost and jeopardize the final result of this important process.

Autoguiding and aggressiveness

On nights of bad seeing, and especially with long focal length guide scopes, it could be worthwhile to slightly defocus the guide star, so that the effect of high-frequency twinkling is mitigated somewhat and the camera won't try to "guide the seeing out".

In practice, the *aggressiveness* parameter defines the "reaction threshold" (in terms of sensor pixels), i.e. the value of the offset between two consecutive exposure cycles above which the camera will make a correction. It can be calculated via the following:

Minimum reaction threshold in pixels = 7 – value of aggressiveness

The lower the aggressiveness, the higher the threshold, and vice-versa. For example, with an aggressiveness value of 2 (LOW), the SmartGuider will make a correction only if the offset is at least 7 -2 = 5 pixels, thereby resulting in a quite

"lazy" behavior. On the contrary, if the aggressiveness is set to 6 (HIGH), even a displacement as small as 7 – 6 = 1 pixel is big enough to trigger correction, which implies a very "reactive" behavior.

During autoguiding, the trend of the X and Y graphs should always be staying as smooth as possible. It is advisable to start off with default values for aggressiveness and guiding speed; then both parameters can be fine tuned to achieve the best possible sync between your SmartGuider and your telescope.

If you notice any significant oscillations about the zero position of one or both graphs (*overcorrection*), the guiding speed should be decreased with the mount keypad until the oscillation becomes less important (ideally, almost negligible). Anyway, it must be noted that a *little* oscillation about the zero position is acceptable since both graphs depict the offset between two consecutive exposures with a 2X scale. So, **two pixels on the tracking graph** are actually equivalent to **one single pixel on the detector**. If the oscillation continues even with the guiding speed at its lowest possible value, the aggressiveness has to be decreased.

In case the profile of one or both graphs keeps steadily above or below the zero value (*undercorrection*), the guiding speed has to be slowly increased until the graph profile goes back to hovering around the zero position. If no improvement is seen even with the guiding speed at its highest value, the aggressiveness must be increased.

Should the graphs still be showing a small, jerky oscillation in spite of the above precautions, please make sure your equipment is properly balanced in both axes.

It must be stressed that a perfect balance of all the weights, the quality and solidity of all the mechanical supports and adapters is of paramount importance in getting round stars and well-tracked exposures! Sometimes, trailing due to differential flexure can ruin your pictures even with apparently smooth tracking.

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5. Technical Specifications

CAMERA

Sensor.....Mono 1/3" Aptina MT9V032
Sensor resolution.....752x480, 6-µm square pixels
Exposure time range.....Auto, 0.001 - 2 seconds
Housing.....Aluminium, with polycarbonate lid
Nosepiece.....Standard 1.25-inch (31.8mm) with filter thread
Connectors.....8-pin RJ45
Size and weight.....D=65mm, H=50mm, Weight: 110g

CONTROL PADDLE

Case……..ABS with side non-slip polyurethane inserts
Keypad.....Three membrane keys with back-illumination
Display.....2.5-inch red graphical LCD, 128x64 pixel resolution
Connectors.....8 pin RJ45, 12V DC jack, 6 pin RJ12 pin
Size and weight.....LxHxD: 55x96x28mm, Weight: 220g
Power requirements…….....8-14V DC,110mA

FEATURES

- *Automatic guide star search*
- *Real-time monitoring of guide star position and focus*
- *Automatic axis calibration with permanent storage of parameters*
- *Adjustable display backlight and buzzer volume.*
- *Adjustable dual-axis aggressiveness*
- *High-precision 2X sub-pixel autoguiding*

GUIDE STAR BRIGHTNESS

60-mm guide scope,2-sec exposure.....approx. 7.5
80-mm guide scope, 2-sec exposure.....approx. 8.0
100-mm guide scope, 2-sec exposure.....approx. 8.5

FIELD WIDTH AND IMAGE SCALE

Scope with F = 300mm.....FOV: 51.7x33.0 arcmin.....scale: 4.13 arcsec/px
Scope with F = 500mm.....FOV: 31.0x19.8 arcmin.....scale: 2.48 arcsec/px
Scope with F = 800mm…....FOV: 19.4x12.4 arcmin…....scale: 1.55 arcsec/px